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Citation Analysis of Fuzzy Set Theory Journals: Bibliometric Insights About Authors and Research Areas

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Abstract Publications on fuzzy set theory and its applications have grown exponentially. The increasing rate of developments in the field is a response to diverse factors, including the need for robust mathematical approaches that model human-like perceptions, values and decision-making processes in complex and dynamic systems. This study presents a citation analysis of 22 narrowly targeted fuzzy set theory journals with a focus on leading authors and research areas. In this paper, bibliometric tools are used for the treatment and analysis of a large amount of data retrieved from the rigorous Web of Science scientific database. The aim of the paper is to offer a general overview of the influence that fuzzy set theory has on academicians and diverse scientific fields. Its objective is to identify connections, trends and opportunities for synergies. The results of over 62,000 published documents, which represent more than 1,300,000 citations in the selected journals, show computer science and engineering as the top citing research fields and authors Xu, Pedrycz and Herrera as the top citing researchers.

Keywords Fuzzy set theory journals · Citation analysis · Authors · Research areas · Bibliometry

1 Introduction

Human expertise, perceptions and intelligence are in many cases necessary elements to include when modeling real-world phenomena [1]. The seminal continuous-valued logic introduced in the mid-1960s by Prof. Lofti Zadeh, fuzzy sets, fuzzy rule base, fuzzy logic, and thus fuzzy set research [2] all address the inclusion and treatment of uncertain elements in a wide range of problems. The incorporation of the fuzzy toolbox, first used in engineering applications [3] and later applied to a plethora of areas such as robotics [4], health disciplines [5], managerial sciences [6] and business economics [7], led to the effective management of imprecise, incomplete, vague, fragmentary, subjective or missing information in complex and human-like dynamic systems [8].

Currently, the concept and treatment of uncertainty are commonly accepted. However, when first introduced, fuzzy logic faced criticism from classical standpoints [9]. Vagueness and ambiguity are concepts that have been traditionally avoided by scientists due to their inherent undesired state of imprecision [10]. Probability theory dealt at first with uncertainty, applied mainly at the level of randomness; nonetheless, numerous problems required further developments. Fuzzy sets provided the measurable framework involving true values ranging from zero to one, yielding membership functions, which were required for advancements in the field. A special case of fuzzy sets was

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then proposed—the possibility theory [11, 12]—and from there a series of extensions in the area were exponentially triggered such as type-2 fuzzy sets [13, 14], intuitionistic fuzzy sets [15], interval-valued intuitionistic fuzzy sets [16, 17], fuzzy multi-sets [18], hesitant fuzzy sets [19], and Pythagorean fuzzy sets [20], among others.

The novel developments in fuzzy set theory are disseminated in diverse scientific journals (see, e.g., [21]). These publications compile original research articles from academics all over the world. The increasing impact of fuzzy developments motivates the analysis of connections, networks and influence that describe the activity of the leaders in the field. The present study proposes the examination of 22 narrowly targeted fuzzy set theory journals (NTFSTJ) to generate a picture of these connections. The selection of these journals is based on the framework proposed by Merigó et al. [9]. More specifically, on their proposed indicator: percentage of fuzzy papers in the journal (%PF). The selected 22 journals, including their %PF retrieved from [9], are as follows: the Iranian Journal of Fuzzy Systems (IrJFS), 98; IEEE Transactions on Fuzzy Systems (TFUZZ), 96.9; Fuzzy Sets and Systems (FSS), 91.7; International Journal of Fuzzy Systems (IJFS), 90.6; Fuzzy Optimization and Decision Making (FODM), 87.4; Journal of Intelligent & Fuzzy Systems (JIFS), 71.3; International Journal of Uncertainty Fuzziness and Knowledge-Based Systems (IJUFKS), 65.4; Soft Computing (SC), 44.1; International Journal of Approximate Reasoning (IJAR), 42.3; International Journal of Intelligent Systems (INT), 40.1; Applied Soft Computing (ASOC), 37; Journal of Multiple-Valued Logic and Soft Computing (JMVLSC), 35.4; International Journal of Computational Intelligence Systems (IJCIS), 30.9; International Journal of General Systems (IJGS), 29.2; Information Sciences (INS), 28.5; Intelligent Automation and Soft Computing (IASC), 22.7; Expert Systems with Applications (ESWA), 22.2; Cybernetics And Systems (C&S), 16.5; International Journal of Information Technology & Decision Making (IJITDM), 16.2; and Knowledge Based Systems (KNOSYS), 11.7. In addition, we have included in the study the journal Kybernetes (Kyb) for its well-known contributions to the field and the journal Information Fusion (INFFUS) for the exceptional performance it has achieved in recent years and for its focus on fuzzy set theory. Note that some top journals that have published many seminal articles connected to fuzzy logic are not included in the analysis because these journals have a broader scope and publish only a small percentage of articles related to fuzzy systems.

Bibliometric studies have recently gained popularity. This increased interest has mainly been triggered by the recent developments in information technologies, the immediateness of information transfer, and the rapidly expanding publication of findings in the fuzzy set theory field. Bibliometric analyses generally involve the study of large amounts of scientifically published documents employing statistical tools. The bibliographic material gathered can range from searches in the title, abstract, or embedded keywords to sophisticated advanced searches with combinations of diverse key elements such as sources of information, research and specific science categories. These options depend on the scientific database consulted. For the specific case of fuzzy set theory, a significant amount of bibliometric studies have been proposed, e.g., [9] offering a general overview of fuzzy set theory field by applying a search process in the WoS Core Collection on papers addressing the word "fuzzy" in the topic section, the authors find a total of 115,000 papers and present a detailed study on 56,500 refined core studies, sectioning them by annual publications, citation structure, most cited papers in fuzzy research, most influential fuzzy research journals, books, authors, organizations and countries. Ref. [22] shows the findings on a bibliometric study of fuzzy set theory articles and reviews based on WoS databases for documents published from 1986 to 2015 that contain the word "fuzzy" in the abstract title or keywords. This search is set specifically for the region—China, People's Republic of China or Chinese—and a total of 12,936 documents are explored using CiteSpace software and sectioned by papers' geographical distribution, international collaborators, top-cited works, top-ranked categories terms and keywords, and a cocitation analysis. Ref. [23] presents a study on the evolution of the fuzzy set theory field with special insights about the contributions of the Spanish community and a comparison to other leading countries in fuzzy set theory research. Here, the authors use the CoPalRed software for a network and a co-word analysis to generate bibliometric maps. Based on the query included, it can be observed that the search process is carried out in WoS for article-type documents including the word "fuzz*" in the topic section or papers published in the journals FSS or TFUZZ and for the countries of Scotland or Japan or Canada or Spain or England or North Ireland or USA or People's Rep. of China or Wales or Germany. Authors show that the resulting query generates a total of 16,344 research documents analyzed by periods of time, thematic networks, and a specific analysis for Spanish institutions and most influential articles. Ref. [24] presents a bibliometric study including the keywords "fuzzy" and "decision-making" in the topic section; from the gross 14,525 published documents matching the criteria, the authors filter results obtained a final pool of 8135 documents ranging from 1970 to 2014, with the resulting selection partitioned and analyzed using the VOS viewer software to identify the top influential journals, papers, authors, and universities using diverse bibliometric indicators. Ref. [25] retrieves the findings for the proposed

search of "linguistic decision making" as the topic in the WoS database, obtaining a total amount of 2017 documents; these results are displayed using CiteSpace software and divided by highly cited authors, journals and subject categories. Ref. [26] discusses the results from a search using the keywords "fuzzy decision*" in the topic section delimited by the years 1900 to 2015 of the WoS database; the resulting 13,901 records were treated using Vantage Point text-mining software aiming to portray 35 years of fuzzy decision research and a dissection on annual trends, regions and countries analyses, most influential institutions and journals, highly cited papers and WoS categories. Ref. [27] shows a review on fuzzy multi-criteria decision-making applications for energy policymaking problems; the authors use preferred reporting items for systematic reviews and meta-analyses, and the search process yields 150 studies that are further analyzed, such that fuzzy AHP in combination with other methods are the most recurrent papers found. Ref. [28] performed a comprehensive literature review from 1984 to 2018 of fuzzy techniques applied to construction project management; their findings are sectioned by decades, and most of the specialized applications in the field are launched in the early 2000s, coinciding with the emergence of information technologies. Finally, [29], using a systematic review of the field of complex fuzzy sets and logic, a recent subarea of fuzzy set theory, performed a citation-like search to the seminal papers [30, 31]; combining it with results from Google Scholar, their findings present a pool of some of the current papers that constitute the main ideas and foundations of this specific subfield of fuzzy sets theory.

The present work presents a citation analysis of authors and research areas using bibliometric tools on 22 NTFSTJ. The aim is to visualize the trends that connect the main leaders of the field and the top citing research areas of each publication. When contrasted with related bibliometric analyses, the originality of the present research lies in the citation search process, which uses not only the direct results from the WoS but also the citation report feature of the database source, adding an in-depth perspective of who and from where the citations of the NTFST journals are coming. In addition, three aggregated results tables are created to see the accumulated figures of the topics of interest. Along with the natural results of compiling and representing large amounts of data in convenient tables, this study offers additional information, including the visualization of connections between researchers and the top research areas that explore fuzzy techniques along with exploring new opportunities for applications in emerging research fields.

The rest of the paper is structured as follows. Section 2 presents the methodology followed for the gathering and treatment of data. Section 3 presents the retrieved structured information, first introducing results for each of the selected NTFSTJs and offering three tables, including the aggregated results. Finally, Sect. 4 presents the concluding comments of the general analysis.

2 Methodology

The scope of bibliometric studies has grown exponentially in recent decades. The main advantage of employing a bibliometric approach in a specific analysis relies on the methodical quantification of the information concentrated in scientific databases [32, 33]. This representation allows a quick understanding of the connections, relations and impact of the studied phenomena, thus proposing both a clear picture of all the relevant elements that shape the field and the areas of opportunity that allow the possibility of generating novel research and synergies (see, e.g., [34]).

When building a bibliometric analysis, a comprehensive, structured and replicable methodology is essential [35]. This study retrieves data from the Web of Science (WoS) scientific database, specifically from its Core Collection. The selection of the WoS database arises from the need for clear and reliable information for constructing bibliometric indicators. It is considered one of the most rigorous and complete scientific databases, therefore ensuring robust information (see [36]). The Core Collection of the WoS includes over 1.5 billion cited references starting from 1900, more than 74.8 total million records, over 21,100 unique global journals and 254 disciplines. To improve the specifications and reproducibility of this study [37], the consulted WoS Core Collection includes the following sub-datasets and coverage periods: Science Citation Index Expanded (SCI-EXPANDED), 1900—present; Social Sciences Citation Index (SSCI), 1900—present; Arts & Humanities Citation Index (A&HCI), 1975—present; Conference Proceedings Citation Index-Science (CPCI-S), 1990—present; Conference Proceedings Citation Index-Social Science & Humanities (CPCI-SSH), 1990—present; Book Citation Index-Science (BKCI-S), 2005—present; Book Citation Index-Social Sciences & Humanities (BKCI-SSH), 2005—present and Emerging Sources Citation Index (ESCI), 2015—present.

2.1 Raw Data Retrieval Process

The following general procedure was performed to collect the information needed for the citation analysis presented in this study. Step 1. The names of each of the selected NTFSTJs, e.g., fuzzy sets and systems, were introduced as keywords in the main search function of the WoS database portal and publication names were searched. The timespan of the search was limited from 1900 to 2018; this range

included data until December 31, 2018. Step 2. The resulting search was then refined by articles, reviews, letters and notes, thus limiting results to citations from these transparent sources. Step 3. From the filtered results, a Citation Report was created using the homonymous function in the WoS portal. Step 4. Next, a second filtering, again for articles, reviews, letters and notes of the results, was performed. Step 5. The resulting data were by this point the raw material used for the generation of the following bibliometric analyses. Step 6. From here, two basic extractions of information were generated: on the one hand, the complete list of authors' papers that cited the selected journal and on the other, the complete list of research areas' papers that cited the selected journals.

The raw data retrieval process was performed from March until September 2019. During these 7 months, most of the time was used in the thorough revision by name, surname and affiliation of the obtained data for authors. The need for this double checking was the fact that the raw retrieved data included in some cases authors that shared the same initials and surname, therefore aggregating their combined results and positioning them in top places. For example, suppose an author had the common initials and surname "J Smith"; this author's complete name could be "John Smith" or "James Smith", but the raw data coming from the database combine the results for author J Smith into a single result, which in our case resulted in a critical miscalculation. This double check was not performed for the research areas, as they included consolidated information previously refined in the WoS.

2.2 Aggregated Initial Results

To fully dimensionalize the obtained results, we first proposed to describe the general scope of the initial aggregated information following the previously defined steps.

Following the raw data retrieval process specifications, for Steps 1 and 2, a total of 62,379 total papers (TP) were found for the 22 NTFSTJ. The initial aggregated results for Steps 3 and 4 show a concentrated number of 1,307,070 total citations (TC) in 448,852 citing papers (CP). Table 1 presents the selected narrowly targeted fuzzy set theory journals with the initial aggregated results from the previously mentioned steps and some performance indicators.

Please observe that the studies published by these 22 journals present an average of 16.68 citations per document, an average impact factor of 3.52 for 2018, and 3.35 for the 5-year impact factor. Table 2 presents the general citation structure of the papers citing the 22 selected NTFSTJ to visualize the current impact of the published research.

The first publications of the selected NTFST journals appeared in 1975. Specifically, 50 publications (TP) were published, of which 38 corresponded to INS and 12 to IJGS. On the other hand, the first citing papers (CP) were published in 1982, and a detailed exploration revealed a total of 220 CP for the selected journals distributed in the following fashion: 3 for C&S, 44 to FSS, 120 for INS, 37 for IJGS and 16 for Kyb. Figure 1 shows the evolution of the TP and CP of the 22 NTFSTJs over time.

3 Results

The collected and treated data are presented in Tables 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24. Each table compiles the top 40 authors and research areas citing the 22 NTFSTJ. Please note that the authors and research areas are ranked by the sum of total citing papers. The resulting tables show 401 different authors with 56,014 total papers and 76 research areas with 813,295 papers.

3.1 Individual Overview of the Selected Journals

ASOC stands as a leading journal in the scientific fields of computer science, artificial intelligence, and interdisciplinary applications. The official aim of the journal is to publish quality research on fuzzy logic, neural networks, evolutionary computing, rough sets and similar techniques to deal with real-world problems. For applied soft computing, Pedrycz, Xu and Castillo lead the rank as the most productive authors, with 183, 170 and 129 total papers cited the journal, respectively. In similar studies, Pedrycz and Castillo are ranked as the 1st and 2nd most productive and influential authors for this particular journal, respectively, and Xu is listed as the 4th most cited author by ASOC papers during 2004–2016 [38]. The journal is mainly cited by papers focused on computer science, engineering and operations research management. A congruency between the results presented and the official aim and scope of the journal is observable, as the categories match.

C&S aims to publish documents for computer and information scientists, systems managers, and researchers in fuzzy systems. The journal seeks to share contributions in management, robotics, linguistics, artificial intelligence, operations, and political science. It is observable that the journal has an orientation to humanities and a combination of state-of-the-art cybernetics and systems methods linked to benefits to humankind, as many of the papers citing the journal belong to research areas such as psychology, behavioral sciences, education philosophy and political science. The leading authors citing this publication are Chen with 90 papers, whose main focus resides in engineering applications, Merigó, who published a total of 65

Table 1 Selected narrowly targeted fuzzy set theory journals

J	TP	TC	CP	TC/TP	H	IF	IF 5	AIS
ASOC	4948	102,946	40,526	21	106	4.873	4.858	0.814
C&S	1327	8296	4563	6	34	1.681	1.319	0.250
ESWA	11,632	286,032	105,064	25	158	4.292	4.577	0.790
FODM	279	5334	2741	19	34	4.128	4.116	0.834
FSS	7571	236,626	57,160	31	180	2.907	2.997	0.630
TFUZZ	2440	141,184	36,334	58	169	8.759	9.438	2.050
INFFUS	633	20,798	7725	33	70	10.716	8.875	1.847
INS	9181	235,095	79,714	26	156	5.524	5.305	1.111
IASC	1005	2704	1437	3	18	0.790	0.854	0.097
IJAR	1742	36,441	14,549	21	82	1.982	2.200	0.603
IJCIS	957	7084	3713	7	33	2.153	1.891	0.322
IJFS	831	7030	3014	8	34	3.085	2.849	0.368
IJGS	1322	18,095	9212	14	56	2.259	2.169	0.543
IJITDM	724	7697	3648	11	36	2.862	2.343	0.397
INT	1737	31,501	12,633	18	77	7.229	5.861	0.827
IJUFKS	1211	18,800	9314	16	54	1.286	1.530	0.272
IrJFS	542	2761	1446	5	21	1.496	1.170	0.202
JIFS	4066	21,372	8424	5	49	1.637	1.782	0.217
JMVLSC	663	3017	1678	5	19	0.613	0.469	0.084
KNOSYS	3470	68,936	25,346	20	93	5.101	5.358	0.994
Kyb	2876	11,218	5655	4	35	1.381	1.231	0.157
SC	3222	34,103	14,956	11	65	2.784	2.600	0.466
Total	62,379	1,307,070	448,852	16.68[a]	71.77[a]	3.52[a]	3.35[a]	0.63[a]

J journal, *TP* sum of journal's published documents, *H* general H index of the journal, *TC* sum of times cited, *TC/TP* ratio: citations per published document, *CP* sum of documents citing the journal, *IF* 2018 JCR impact factor, *IF 5* 2018 JCR 5-year impact factor, *AIS* 2018 article influence score

[a]Average

Table 2 General citation structure of the papers citing the selected journals

Number of citations	Number of publications	% Papers
≥ 1000	191	0.043
≥ 500	709	0.158
≥ 250	2527	0.563
≥ 100	13,274	2.957
< 100	432,151	96.279
Total	448,852	100

papers and whose main areas of interest are computer science and information systems and Szczerbicki with a total of 61 papers. This last author focuses on computer science and cybernetics.

ESWA is focused on the exchange of information related to expert and intelligent systems linked to applications in industry, government and universities. Fuzzy systems are intrinsically linked to expert and intelligent systems, and the connection between these two fields of knowledge can be tracked back to the foundations of fuzzy set theory [39], which are the reasons for the relevance of the journal ESWA and the critical developments published in it. The results show that most of the papers citing the journal have a robust technical approach to computer engineering and operations research management science; however, sciences such as business economics, social sciences and public administration are also influenced by ESWA. For authors, the one with the most papers citing the journal is Zavadskas, whose publications are oriented to economics, business and engineering, followed by Xu, who focuses on computer science and artificial intelligence, and Kumar, whose research interests are in electrical and electronic engineering, materials and chemistry sciences.

FODM is a journal mainly dedicated to practical issues and theoretical developments of fuzzy optimization and decision-making in uncertain conditions [40]. It promotes advances in fuzzy technology and soft computing methodologies aiming to understand, model and optimize economic, engineering, management, and societal problems. Some of the main authors citing this journal are Herrera-Viedma, whose main specialization is computer

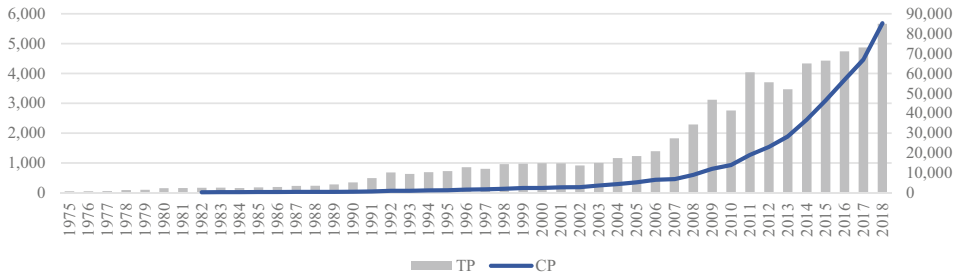

Fig. 1 Number of annual publications citing the selected fuzzy set theory journals

science information systems; Liao, whose main publications are on computer science artificial intelligence; and Yager, who focuses on computer science artificial intelligence and computer science theory methods. Some of the most citing research areas fall in technical categories such as computer science, engineering and mathematics. Business economics is 5th in the ranking; however, aside from that area and social sciences, the other topics show a more technical orientation.

One of the classic journals in fuzzy sets theory, systems and applications is FSS. The journal was launched in 1978. Its scope covers advances made on a wide range of aspects of fuzzy sets, e.g., fuzzy set mathematics, such as category theory, topology, algebra and statistical methods; information technologies, namely neural networks, clustering, data analysis and data fusion, pattern recognition and computer vision; other fields, such as calculus of fuzzy numbers, measures of information content, aggregation operations, and theory of relations. In essence, the journal publishes relevant developments that build the connection between human representations and the processing capability of computers. For citing authors, the results show Pedrycz in the first position with a total of 608 papers citing the journal, 55% more papers than the following author in the list, Xu with a total of 390 publications, and Mesiar with 324 publications. The results also show computer science, engineering, mathematics and automation control systems as the main research areas citing this journal, which demonstrates a clear technical approach to the papers influenced by FSS.

TFUZZ is also a classic journal in the theory, design and application of fuzzy systems. This journal's first issue was launched in 1993 with an editorial note by [41] and compiles exploratory and application studies on fuzzy systems. Special emphasis is not only given to engineering applications, but it is also common to find letters, comments and rebuttals connected to published studies. Ref. [42] has recently published a study on the structure and citation landscape of the journal; another interesting compilation is [43] with a celebration article of the 25th anniversary of the journal. For this journal, Pedrycz is also leading the ranking with a citation count of 419 papers, followed by Xu with 365 and Shi with 354 papers citing the journal. For research areas, the specialization of the journal mainly attracts the attention of studies with a focus on computer science, engineering and automation control systems; these top citing areas are followed by several other technical collections.

INFFUS's first issue was published in the year 2000; despite being a relatively recent journal, it has managed to publish top-cited articles, enabling the journal to achieve the largest impact factor among the 22 journals presented in this paper. INFFUS is focused on publishing original papers, letters and occasional reviews in multisensor, multisource, and multiprocess information fusion applications, architectures and algorithms. The scope of the journal allows the combination of many advances in fuzzy set theory, such as fuzzy decision-making and group decision-making, fuzzy aggregations, fuzzy clustering, fuzzy multiattribute methods, etc. Xu leads the citation ranking with a total of 132 papers, closely followed by Herrera with 110 and Liu with a total of 82. The highest number of papers citing for this specific journal comes from technical research areas such as computer science, engineering, telecommunications, physics, and optics mathematics.

The main purpose of INS is to publish original research in the areas of information, knowledge engineering and intelligent systems and a wide range of related fields of knowledge, such as mathematics, physics, statistics, management science, and biology [44]. The first issue of INS was launched in 1968, and until 2018, it included approximately 9300 documents in the WoS. The journal promotes state-of-the-art developments in areas such as information theory, artificial intelligence and soft computing, including fuzzy systems. INS also publishes applications in manufacturing, machine–man interfaces, finance and economic modeling and optimization. For this journal, Pedrycz is the most citing author with a total number of 459 papers, Xu is the second most citing author of the journal with 430 papers and Herrera is the third with 324 publications. Computer science, engineering and mathematics are the top citing research areas; managerial sciences such as business economics stand in eighth place;

Table 3 Applied soft computing

R	AT	TPC-A	RA	TPC-RA
1	W Pedrycz	183	Computer Science	23,884
2	ZS Xu	170	Engineering	18,751
3	O Castillo	129	Operations Research Management Science	4112
4	A Kumar	124	Mathematics	3622
5	XH Chen	121	Automation Control Systems	2857
6	EK Zavadskas	114	Science Technology Other Topics	2717
7	PD Liu	109	Telecommunications	2236
8	JM Merigó	105	Energy Fuels	2202
9	H Garg	105	Business Economics	1533
10	F Herrera	104	Environmental Sciences Ecology	1531
11	P Melin	102	Instruments Instrumentation	1340
12	S Shamshirband	89	Mechanics	1226
13	GW Wei	88	Physics	1169
14	A Abraham	86	Materials Science	1163
15	R Tavakkoli-Moghaddam	81	Chemistry	1091
16	E Herrera-Viedma	79	Thermodynamics	858
17	JQ Wang	78	Water Resources	809
18	LC Jiao	75	Mathematical Computational Biology	628
19	Y Deng	70	Transportation	602
20	C Kahraman	70	Geology	539
21	SM Mousavi	69	Robotics	525
22	A Kaveh	68	Optics	435
23	PN Suganthan	67	Construction Building Technology	425
24	JZ Wang	65	Electrochemistry	423
25	JZ Zhou	65	Neurosciences Neurology	396
26	E Cuevas	64	Imaging Science Photographic Technology	391
27	D Petkovic	59	Medical Informatics	334
28	PC Chang	59	Remote Sensing	303
29	QK Pan	59	Agriculture	268
30	S Salcedo-Sanz	56	Metallurgy Metallurgical Engineering	259
31	T Chen	55	Acoustics	250
32	HY Zhang	55	Biochemistry Molecular Biology	214
33	MG Gong	54	Meteorology Atmospheric Sciences	204
34	A Baykasoglu	52	Information Science Library Science	203
35	XD Liu	52	Radiology Nuclear Medicine Medical Imaging	188
36	N Chakraborti	49	Life Sciences Biomedicine Other Topics	164
37	TY Chen	49	Health Care Sciences Services	160
38	L Li	48	Social Sciences Other Topics	147
39	CP Lim	48	Biotechnology Applied Microbiology	137
40	J Wang	45	Physical Geography	114

R ranking, *AT* author, *TPC-A* sum of total publications citing the journal by author, *RA* research area, *TPC-RA* sum of total publications citing the journal by research area

and the next is mathematical methods in the social sciences, which appears in last place in the ranking.

IASC published its first issue in 1995 and collected approximately 1067 documents by 2018. The journal has a wide range of interests, such as engineering, computer science, intelligent automation, control, manufacturing, modeling and systems engineering. The main scope of the journal includes original and survey papers in intelligent automation and soft computing, i.e., fuzzy logic studies. The most citing author for this publication is Lucas with 14 papers, followed by Waxman with 13 and Wang with 12. It is observable that the journal has a more technical

Table 4 Cybernetics and systems

R	AT	TPC-A	RA	TPC-RA
1	SM Chen	90	Computer Science	2736
2	JM Merigó	65	Engineering	1151
3	E Szczerbicki	61	Mathematics	572
4	C Sanin	48	Operations Research Management Science	397
5	YG Zhu	47	Business Economics	309
6	NT Nguyen	34	Automation Control Systems	303
7	JL Uso-Domenech	33	Psychology	164
8	JJ Jung	32	Environmental Sciences Ecology	163
9	M Lloret-Climent	29	Science Technology Other Topics	160
10	M Sakawa	26	Physics	126
11	PD Liu	26	Neurosciences Neurology	120
12	M Grana	24	Social Sciences Other Topics	115
13	SZ Zeng	23	Telecommunications	115
14	E Nissan	22	Robotics	103
15	H Sabelli	22	Behavioral Sciences	78
16	M Mulej	21	Information Science Library Science	76
17	A Whiten	21	Instruments Instrumentation	72
18	JA Nescolarde-Selva	21	Mathematical Computational Biology	72
19	U Yolcu	20	Life Sciences Biomedicine Other Topics	62
20	E Egrioglu	20	Mechanics	54
21	J Wang	20	Zoology	48
22	M Casanovas	19	Chemistry	46
23	MR Meybodi	19	Energy Fuels	40
24	P Singh	19	Materials Science	39
25	Y Deng	18	Education Educational Research	36
26	J Kacprzyk	18	Water Resources	36
27	C Toro	17	Transportation	34
28	AM Gil-Lafuente	17	Geology	32
29	H Prade	16	Medical Informatics	30
30	JA Torkestani	16	Mathematical Methods in Social Sciences	29
31	CH Aladag	15	Public Administration	29
32	K Dautenhahn	15	Philosophy	26
33	DB Fogel	15	Geography	23
34	R Gutierrez	15	History Philosophy of Science	23
35	JG Polhill	15	Anthropology	22
36	Y Lin	15	Imaging Science Photographic Technology	21
37	W Pedrycz	15	Acoustics	19
38	RR Yager	15	Electrochemistry	19
39	D Dubois	14	Agriculture	18
40	A Nafidi	14	Sociology	18

influence, as the top citing research areas are computer science, engineering, and automation control systems, among others. It is interesting that health areas such as medical informatics, genetics and oncology are included in the top citing research areas.

The IJAR specific scope is the treatment of imprecision and uncertainty in artificial and computational intelligence in both state-of-the-art developments and innovative applications. This journal launched its first issue in 1987, and by the close of 2018, it compiled 1060 articles in the WoS Core Collection. Some of the topics covered by this journal are probabilistic reasoning, possibility theory, random sets, fuzzy sets, rough sets, decision theory, uncertain reason systems such as risk analysis, information fusion, machine learning, computer vision, and intelligent data analysis. Xu is the top citing author for IJAR with a total of

Table 5 Expert systems with applications

R	AT	TPC-A	RA	TPC-RA
1	EK Zavadskas	292	Computer Science	54,708
2	ZS Xu	251	Engineering	48,917
3	A Kumar	234	Operations Research Management Science	17,659
4	XH Chen	205	Business Economics	9697
5	W Pedrycz	205	Mathematics	6895
6	S Shamshirband	195	Science Technology Other Topics	6539
7	Q Zhang	194	Environmental Sciences Ecology	5459
8	C Kahraman	193	Automation Control Systems	5417
9	Y Deng	190	Telecommunications	4595
10	TP Hong	160	Energy Fuels	3727
11	UR Acharya	157	Instruments Instrumentation	3116
12	F Herrera	156	Chemistry	2758
13	Y Xu	154	Physics	2545
14	JQ Wang	154	Materials Science	2452
15	S Kumar	154	Transportation	2371
16	W Wang	150	Information Science Library Science	2318
17	GW Wei	143	Mechanics	1915
18	A Azadeh	142	Water Resources	1741
19	R Tavakkoli-Moghaddam	141	Medical Informatics	1598
20	O Castillo	141	Mathematical Computational Biology	1587
21	M Tavana	137	Thermodynamics	1474
22	D Petkovic	133	Geology	1304
23	FTS Chan	133	Construction Building Technology	1299
24	GH Tzeng	128	Electrochemistry	1259
25	SM Mousavi	128	Education Educational Research	1215
26	GH Huang	124	Social Sciences Other Topics	1188
27	SM Chen	113	Neurosciences Neurology	1162
28	JZ Zhou	113	Agriculture	1003
29	PC Chang	111	Health Care Sciences Services	875
30	JP Xu	111	Optics	852
31	P Melin	111	Imaging Science Photographic Technology	850
32	V Kumar	108	Psychology	809
33	PD Liu	106	Robotics	803
34	E Cuevas	100	Remote Sensing	784
35	K Govindan	97	Radiology Nuclear Medicine Medical Imaging	612
36	JM Merigó	95	Biochemistry Molecular Biology	558
37	SY Sohn	92	Meteorology Atmospheric Sciences	546
38	AH Gandomi	92	Public Administration	535
39	LG Zhou	87	Public Environmental Occupational Health	519
40	JJ Jung	80	Food Science Technology	511

225 papers, followed by Pedrycz with 165, Herrera with 155 documents, Mesiar citing 102 and Yager with 92. Computer science, engineering, mathematics, operations research and automation and control systems are some of the top citing research areas for this journal.

IJCIS is a journal that launched in 2008 and had 980 documents in the WoS by the end of 2018. This periodical is fully oriented toward publishing original papers in aspects of applied computational intelligence, with special emphasis on papers focused on fuzzy logic, neural networks, evolutionary computation and probabilistic reasoning, and a wide range of applications, including data science, data mining, system control and bioinformatics. The results show that this journal's top citing authors are Wang with 77 papers, Wei with 70, Liu with 67, Herrera citing 65 and Xu with 64 documents. For research areas,

Table 6 Fuzzy optimization and decision making

R	AT	TPC-A	RA	TPC-RA
1	ZS Xu	160	Computer Science	2100
2	E Herrera-Viedma	59	Engineering	693
3	HC Liao	47	Mathematics	538
4	RR Yager	44	Operations Research Management Science	537
5	XH Chen	41	Business Economics	180
6	GW Wei	41	Automation Control Systems	150
7	DF Li	39	Science Technology Other Topics	143
8	FY Meng	38	Telecommunications	73
9	TY Chen	36	Environmental Sciences Ecology	67
10	JQ Wang	35	Energy Fuels	32
11	JM Merigó	35	Mechanics	31
12	YG Zhu	33	Water Resources	28
13	YC Dong	33	Physics	27
14	F Chiclana	31	Social Sciences Other Topics	27
15	K Yao	29	Robotics	21
16	JP Xu	28	Geology	16
17	JW Gao	27	Transportation	14
18	F Herrera	26	Materials Science	12
19	HY Chen	25	Mathematical Methods in Social Sciences	12
20	C Kahraman	25	Thermodynamics	12
21	SP Wan	24	Information Science Library Science	9
22	J Zhou	24	Instruments Instrumentation	9
23	DJ Yu	23	Meteorology Atmospheric Sciences	9
24	L Martinez	22	Neurosciences Neurology	9
25	DA Ralescu	22	Construction Building Technology	8
26	PD Liu	22	Chemistry	7
27	YJ Xu	21	Public Environmental Occupational Health	7
28	RQ Zhao	20	Agriculture	5
29	B Oztaysi	20	Education Educational Research	5
30	YH Sheng	20	Mining Mineral Processing	5
31	ML Wen	20	Public Administration	5
32	EK Zavadskas	19	Geography	3
33	LG Zhou	19	Health Care Sciences Services	3
34	J Peng	19	Physical Geography	3
35	XW Liu	18	Remote Sensing	3
36	XL Zhang	18	Food Science Technology	2
37	XX Huang	18	Mathematical Computational Biology	2
38	FJ Cabrerizo	18	Optics	2
39	H Ke	17	Pharmacology Pharmacy	2
40	W Pedrycz	17	Urban Studies	2

computer science, engineering, mathematics, and operations research management science are some of the top citing fields in IJCIS.

The IJFS journal publishes original research, reviews, surveys and expository essays on theory, design and application of fuzzy systems, soft computing systems, gray systems, and other theory systems [45]. This journal publishes 6 issues per year and compiled approximately 980 documents in the WoS from 2008 until 2018. Some of the top citing authors are Wang with a total of 88 documents, Wei with 87, Merigó with 73 papers, Xu with 56 and Liu with 52. IJFS is the official journal of Taiwan Fuzzy Systems Association (TFSA). The main citing research areas of this IJFS are computer science, engineering, automation and control systems; some other interesting research areas are oceanography, instrument instrumentation and geology.

Table 7 Fuzzy sets and systems

R	AT	TPC-A	RA	TPC-RA
1	W Pedrycz	608	Computer Science	35,264
2	ZS Xu	390	Engineering	17,302
3	R Mesiar	324	Mathematics	15,668
4	GH Huang	303	Automation Control Systems	5542
5	RR Yager	302	Operations Research Management Science	5440
6	F Herrera	244	Business Economics	2509
7	SC Tong	216	Science Technology Other Topics	2214
8	D Dubois	215	Environmental Sciences Ecology	1786
9	B De Baets	199	Instruments Instrumentation	1209
10	C Kahraman	191	Mechanics	1032
11	H Prade	185	Physics	931
12	SM Chen	185	Water Resources	859
13	B Davvaz	180	Telecommunications	751
14	H Bustince	175	Energy Fuels	722
15	E Herrera-Viedma	171	Geology	566
16	YP Li	149	Transportation	556
17	PD Liu	146	Robotics	538
18	P Shi	133	Materials Science	478
19	XH Chen	130	Chemistry	439
20	HK Lam	129	Agriculture	323
21	EE Kerre	123	Imaging Science Photographic Technology	306
22	XD Liu	123	Construction Building Technology	291
23	JM Zhan	120	Social Sciences Other Topics	288
24	JJ Buckley	116	Thermodynamics	277
25	JM Merigó	113	Mathematical Methods in Social Sciences	272
26	HX Li	112	Remote Sensing	270
27	YB Jun	111	Information Science Library Science	266
28	T Allahviranloo	108	Medical Informatics	256
29	SK Oh	107	Neurosciences Neurology	254
30	JP Xu	106	Mathematical Computational Biology	231
31	M Sakawa	104	Physical Geography	225
32	O Castillo	101	Psychology	184
33	A Kumar	100	Meteorology Atmospheric Sciences	183
34	M Maiti	99	Optics	181
35	A Kandel	95	Acoustics	173
36	IB Turksen	94	Geography	152
37	J Kacprzyk	93	Biochemistry Molecular Biology	130
38	DH Hong	93	Electrochemistry	129
39	Y Xu	91	Oceanography	129
40	ES Lee	91	Food Science Technology	127

IJGS primarily publishes original research, book reviews, bibliographies and letters on system science, in this case, concepts' methods, principles, theories and experimental results on a wide range of systems. The major focus of the journal is on uncertainty, randomness, fuzziness and imprecision, learning systems, complex systems, and inductive and deductive reasoning about systems. Its objective is to publish novel transversal research that is applicable to diverse phenomena. IJGS started publishing in 1974 and had compiled approximately 1600 documents in the WoS. Xu is the most citing author, with a total of 202 citing documents, followed by Yager with 166, Wang with 109, Pedrycz with 95 and Wei with a count of 85. Computer science is the research area with the most influence by this journal, with a total of 5917 citing documents, followed by engineering and mathematics. It is observable

Table 8 IEEE transactions on fuzzy systems

R	AT	TPC-A	RA	TPC-RA
1	W Pedrycz	419	Computer Science	23,659
2	ZS Xu	365	Engineering	15,769
3	P Shi	354	Automation Control Systems	8519
4	SC Tong	262	Mathematics	5976
5	YM Li	219	Operations Research Management Science	2583
6	F Herrera	211	Instruments Instrumentation	2099
7	HR Karimi	202	Telecommunications	1269
8	GH Yang	173	Science Technology Other Topics	1078
9	RR Yager	166	Mechanics	822
10	R Mesiar	155	Physics	705
11	HK Lam	154	Robotics	685
12	H Bustince	145	Business Economics	653
13	ZD Wang	145	Environmental Sciences Ecology	443
14	HG Zhang	142	Energy Fuels	440
15	CLP Chen	142	Chemistry	378
16	E Herrera-Viedma	138	Imaging Science Photographic Technology	347
17	B Jiang	135	Materials Science	309
18	O Castillo	130	Neurosciences Neurology	290
19	SM Chen	115	Transportation	290
20	G Feng	114	Mathematical Computational Biology	273
21	JB Park	111	Remote Sensing	248
22	HJ Gao	110	Water Resources	206
23	CM Lin	110	Medical Informatics	195
24	PD Liu	108	Acoustics	185
25	B Chen	106	Thermodynamics	184
26	YH Joo	106	Geology	177
27	ST Wang	106	Electrochemistry	173
28	JM Merigó	105	Optics	166
29	JH Park	99	Radiology Nuclear Medicine Medical Imaging	131
30	CJ Lin	98	Biochemistry Molecular Biology	117
31	QL Zhang	96	Construction Building Technology	116
32	JM Mendel	96	Oceanography	109
33	R Sakthivel	96	Geochemistry Geophysics	108
34	CT Lin	94	Information Science Library Science	92
35	JB Qiu	91	Metallurgy Metallurgical Engineering	85
36	LG Wu	91	Social Sciences Other Topics	85
37	CF Juang	88	Meteorology Atmospheric Sciences	84
38	C Lin	85	Physical Geography	75
39	BS Chen	85	Biotechnology Applied Microbiology	74
40	B De Baets	80	Agriculture	73

that this journal has a wide range of transversal topics, as some other top citing research areas are business economics, psychology, life sciences and public administration.

The IJITDM periodically focuses on publishing theoretical and empirical original research on information technology and topics on decision-making techniques [46]. This journal provides a forum for researchers on a wide range of topics, such as artificial intelligence and decision-making, data mining, data clustering, decision support systems, fuzzy logic and the internet, group decision-making and software, information overload, and multiple criteria decision-making in information technology, optimization systems and web-based language, among other topics. The IJITDM first issue was launched in 2010, and it had 786 documents cataloged in the WoS, information

Table 9 Information fusion

R	AT	TPC-A	RA	TPC-RA
1	ZS Xu	132	Computer Science	5469
2	F Herrera	110	Engineering	3215
3	Y Liu	82	Telecommunications	1013
4	JQ Wang	62	Instruments Instrumentation	678
5	HY Chen	61	Mathematics	579
6	PD Liu	60	Automation Control Systems	521
7	E Herrera-Viedma	59	Operations Research Management Science	464
8	XH Chen	58	Chemistry	427
9	YC Dong	49	Imaging Science Photographic Technology	374
10	LG Zhou	48	Science Technology Other Topics	355
11	HC Liao	44	Remote Sensing	353
12	H Bustince	39	Electrochemistry	338
13	FY Meng	38	Optics	326
14	F Chiclana	37	Physics	322
15	YJ Xu	35	Business Economics	181
16	Q Zhang	34	Environmental Sciences Ecology	181
17	L Martinez	33	Transportation	145
18	JM Merigó	31	Robotics	119
19	GW Wei	31	Mathematical Computational Biology	108
20	R Mesiar	30	Materials Science	100
21	ZL Deng	29	Neurosciences Neurology	99
22	B Krawczyk	29	Medical Informatics	94
23	JY Ma	28	Geochemistry Geophysics	88
24	R Sabourin	28	Radiology Nuclear Medicine Medical Imaging	86
25	SP Wan	28	Energy Fuels	70
26	M Wozniak	28	Physical Geography	68
27	W Pedrycz	28	Geology	67
28	HY Zhang	27	Information Science Library Science	57
29	P Zhang	27	Psychology	56
30	SZ Zeng	25	Mechanics	52
31	Y Deng	25	Health Care Sciences Services	50
32	SL Sun	25	Biochemistry Molecular Biology	48
33	SY Huang	24	Construction Building Technology	46
34	JY Dong	24	Social Sciences Other Topics	39
35	A Fernandez	24	Life Sciences Biomedicine Other Topics	38
36	HM Wang	23	Agriculture	33
37	T Denoeux	22	Acoustics	31
38	JP Liu	22	Water Resources	31
39	Y Ma	22	Public Environmental Occupational Health	27
40	ZM Zhang	22	Meteorology Atmospheric Sciences	25

through 2018. The top citing authors are Xu with 103, followed by Zavadskas with 100 documents, Herrera-Viedma with 69 and Kou and Wei with 53 documents each. Research areas with the most influence are computer science, operations research management science, engineering, business economics and mathematics. The transversal applications of this journal's publications are evidenced by the top citing areas, such as healthcare sciences, geology, forestry and oceanography.

INT is a specialized publication that aims to distribute new developments in the field of intelligent systems such as analysis creation, information retrieval, and man–computer interactions, among others [47]. The journal clearly identifies its readership as computer scientists, engineers, cognitive scientists, knowledge engineers, logicians and

Table 10 Information sciences

R	AT	TPC-A	RA	TPC-RA
1	W Pedrycz	459	Computer Science	51,706
2	ZS Xu	430	Engineering	25,534
3	F Herrera	324	Mathematics	11,924
4	RR Yager	259	Automation Control Systems	6772
5	Y Xu	223	Operations Research Management Science	6002
6	B Davvaz	220	Telecommunications	4843
7	P Shi	218	Science Technology Other Topics	3366
8	R Mesiar	208	Business Economics	2372
9	YM Li	195	Physics	2344
10	O Castillo	195	Instruments Instrumentation	2081
11	E Herrera-Viedma	188	Environmental Sciences Ecology	1415
12	M Akram	173	Chemistry	1291
13	C Kahraman	169	Mechanics	1275
14	CC Chang	165	Energy Fuels	1145
15	JM Zhan	158	Mathematical Computational Biology	928
16	H Bustince	156	Materials Science	859
17	A Kumar	146	Neurosciences Neurology	842
18	P Melin	146	Imaging Science Photographic Technology	811
19	D Dubois	142	Optics	760
20	JM Merigó	141	Information Science Library Science	743
21	GH Huang	139	Robotics	682
22	XH Chen	135	Remote Sensing	598
23	H Prade	128	Medical Informatics	569
24	UR Acharya	127	Electrochemistry	565
25	YB Jun	125	Thermodynamics	535
26	SM Chen	123	Water Resources	532
27	SC Tong	123	Transportation	527
28	SM Zhong	122	Biochemistry Molecular Biology	524
29	JP Xu	117	Geology	425
30	B De Baets	115	Psychology	372
31	HY Chen	111	Physical Geography	313
32	CLP Chen	110	Social Sciences Other Topics	302
33	H Fujita	108	Radiology Nuclear Medicine Medical Imaging	291
34	HR Karimi	108	Construction Building Technology	273
35	JQ Wang	105	Education Educational Research	268
36	L Martinez	103	Biotechnology Applied Microbiology	256
37	JY Liang	103	Life Sciences Biomedicine Other Topics	248
38	ZD Wang	102	Health Care Sciences Services	239
39	A Abraham	102	Agriculture	209
40	PD Liu	100	Mathematical Methods in Social Sciences	179

information scientists. Its first issue was introduced in 1986 with an editorial of Ronald R. Yager. By 2018, this journal exhibited 1818 indexed documents in the WoS. The top citing authors for this journal are Xu with 368 documents citing, Yager with a total of 202 documents, Herrera with 174 publications, Herrera-Viedma with 141 total articles and Merigó with 136 documents. The journal has clearly identified their audience as the top citing research areas are computer science, engineering and mathematics. Interesting top citing research fields appear, such as neurology and nuclear science.

IJUFKS is a specialized journal for imprecise, vague, uncertain or incomplete information studies [48]. The scope of this publication is theoretical and methodological research on diverse kinds of methods for the manipulation of imperfect pieces of knowledge. The journal excludes

Table 11 Intelligent automation and soft computing

R	AT	TPC-A	RA	TPC-RA
1	C Lucas	14	Computer Science	708
2	DJ Waxman	13	Engineering	527
3	JQ Wang	12	Automation Control Systems	366
4	H Ghenniwa	11	Telecommunications	98
5	SX Yang	11	Mathematics	97
6	YX Miao	10	Robotics	95
7	WM Shen	10	Instruments Instrumentation	91
8	AA Maciejewski	9	Chemistry	69
9	F Karaca	8	Science Technology Other Topics	64
10	Y He	8	Agriculture	59
11	CM Lin	8	Operations Research Management Science	55
12	S Dormido	7	Environmental Sciences Ecology	45
13	P Cortes	7	Electrochemistry	39
14	E Lotfi	7	Materials Science	37
15	JH Wang	7	Physics	34
16	O Alagha	6	Remote Sensing	33
17	LA De	6	Energy Fuels	32
18	SK Duan	6	Neurosciences Neurology	30
19	PF Jia	6	Imaging Science Photographic Technology	25
20	RG Roberts	6	Biochemistry Molecular Biology	23
21	JD Rubio	6	Optics	23
22	KK Tan	6	Business Economics	20
23	XP Chen	6	Pharmacology Pharmacy	19
24	Q Cao	6	Education Educational Research	17
25	E Daryabeigi	6	Food Science Technology	16
26	V Santibanez	6	Mechanics	16
27	R Khosla	5	Cell Biology	13
28	C Kim	5	Endocrinology Metabolism	13
29	DH Kim	5	Thermodynamics	13
30	R Langari	5	Mathematical Computational Biology	12
31	TH Lee	5	Transportation	11
32	K Nakamatsu	5	Genetics Heredity	10
33	N Suetake	5	Medical Informatics	10
34	G Abbas	5	Oncology	10
35	MR Akbarzadeh-T	5	Public Environmental Occupational Health	10
36	HPH Anh	5	Biotechnology Applied Microbiology	9
37	H Bevrani	5	Plant Sciences	9
38	F Jimenez	5	Toxicology	9
39	H Zhang	4	Water Resources	9
40	KK Ahn	4	Acoustics	8

results of pure mathematics such as fuzzy topology and fuzzy algebra or simple applications of published theoretical results. Its published applications cover intelligent systems, decision-making systems, information fusion and retrieval, data science, and robotics, among others. Some of the methods covered by this journal are nonstandard logics, deep learning, fuzzy data analysis and Bayesian systems. The top citing authors for this journal include Xu with 173 documents, Mesiar with 135 citing papers, Merigó with 116 published works, Wei with 112 and Herrera-Viedma with 95. The top citing research areas include classic computer science, engineering and mathematics, along with other fields such as operations research management science, business economics and telecommunications.

The IrJFS is a specialized journal in fuzzy sets, systems theories and applications. Its main scope is original

Table 12 International journal of approximate reasoning

R	AT	TPC-A	RA	TPC-RA
1	ZS Xu	225	Computer Science	11,116
2	W Pedrycz	165	Engineering	3503
3	F Herrera	155	Mathematics	2539
4	R Mesiar	102	Operations Research Management Science	1218
5	RR Yager	92	Automation Control Systems	768
6	D Dubois	91	Science Technology Other Topics	628
7	E Herrera-Viedma	84	Business Economics	511
8	GW Wei	81	Environmental Sciences Ecology	363
9	H Bustince	79	Telecommunications	279
10	B De Baets	70	Physics	179
11	H Prade	67	Mathematical Computational Biology	159
12	T Denoeux	66	Instruments Instrumentation	157
13	YY Yao	59	Water Resources	140
14	TR Li	58	Energy Fuels	133
15	L Martinez	57	Robotics	130
16	J Wang	55	Medical Informatics	127
17	I Couso	51	Chemistry	108
18	JM Merigó	50	Mechanics	104
19	A Skowron	49	Geology	102
20	XH Chen	49	Philosophy	98
21	XW Liu	48	Information Science Library Science	95
22	L Sanchez	48	Neurosciences Neurology	94
23	BQ Hu	48	Psychology	93
24	YH Qian	47	Transportation	92
25	YJ Xu	45	Social Sciences Other Topics	91
26	O Cordon	45	Biochemistry Molecular Biology	91
27	P Larranaga	45	Imaging Science Photographic Technology	90
28	E Miranda	45	Remote Sensing	80
29	S Moral	45	Mathematical Methods in Social Sciences	79
30	S Destercke	45	Materials Science	78
31	JY Liang	43	Physical Geography	58
32	DQ Miao	43	Public Environmental Occupational Health	56
33	Y Deng	42	Construction Building Technology	55
34	W Zhu	42	Meteorology Atmospheric Sciences	53
35	M Zaffalon	42	Biotechnology Applied Microbiology	51
36	HY Chen	42	History Philosophy of Science	49
37	GH Huang	41	Electrochemistry	47
38	SM Chen	41	Thermodynamics	45
39	WZ Wu	41	Life Sciences Biomedicine Other Topics	41
40	PD Liu	40	Health Care Sciences Services	40

research in finance and management, mathematics, robotics, uncertainty modeling, soft computing, decision-making, and deep learning, such as artificial intelligence, pattern recognition and image processing. This journal's first issue was launched in March 2004. By the end of 2018, this journal's publications in the WoS reached 549. Among the top citing authors for this journal, we can find Wei with 71 documents, Davvaz with 56, Shi with a total of 36, Pang with 28 and Zhan with 20 papers. For top citing documents in the research areas, we can see a clear preference from technical fields such as computer science, mathematics engineering, science technology and automation control systems.

The IJFS disseminates results on cross-section, broad and novel current and potential applications and case studies in the field of fuzzy and intelligent systems. The

Table 13 International journal of computational intelligence systems

R	AT	TPC-A	RA	TPC-RA
1	JQ Wang	77	Computer Science	2631
2	GW Wei	70	Engineering	1101
3	PD Liu	67	Mathematics	460
4	F Herrera	65	Operations Research Management Science	335
5	ZS Xu	64	Science Technology Other Topics	311
6	L Martinez	60	Automation Control Systems	224
7	C Kahraman	55	Business Economics	198
8	JM Merigó	47	Telecommunications	178
9	HY Zhang	39	Environmental Sciences Ecology	121
10	XH Chen	35	Transportation	83
11	DF Li	32	Physics	67
12	D Liu	31	Geology	64
13	B Pradhan	30	Energy Fuels	54
14	Y Xu	30	Instruments Instrumentation	47
15	TR Li	29	Mechanics	46
16	EK Zavadskas	28	Neurosciences Neurology	46
17	SP Wan	26	Chemistry	45
18	RM Rodriguez	26	Materials Science	42
19	M Pal	26	Water Resources	32
20	E Herrera-Viedma	25	Thermodynamics	30
21	SZ Zeng	22	Robotics	28
22	HY Chen	22	Mathematical Computational Biology	27
23	YC Dong	22	Public Environmental Occupational Health	27
24	DJ Yu	22	Information Science Library Science	26
25	J Liu	22	Social Sciences Other Topics	24
26	W Pedrycz	22	Biochemistry Molecular Biology	22
27	XF Zhao	21	Medical Informatics	20
28	E Zio	21	Remote Sensing	20
29	B Oztaysi	21	Psychology	19
30	H Bustince	21	Education Educational Research	18
31	J Wang	20	Imaging Science Photographic Technology	17
32	XW Liu	20	Meteorology Atmospheric Sciences	17
33	SC Onar	19	Nuclear Science Technology	17
34	G Buyukozkan	19	Electrochemistry	16
35	YJ Xu	19	Health Care Sciences Services	15
36	H Rashmanlou	18	Optics	15
37	Y Deng	18	Pharmacology Pharmacy	14
38	JY Dong	17	Physical Geography	13
39	LG Zhou	17	Research Experimental Medicine	13
40	DC Liang	16	Agriculture	12

journal aims to publish works in technical areas such as engineering, civil engineering, manufacturing, industrial, chemical, electrical, biomedical, management and electronic engineering along with soft sciences, social and environmental developments. The journal published its first issue in 1993 with a foreword from L. Zadeh. By the end of 2018, the number of documents indexed in the WoS for this journal was 4128. The top five citing authors for this journal are Xu with 138 papers, Liu with 122, Davvaz with 115, Wang with 115 and Wei with a total of 92 citing publications. The top citing research areas for this specific publication are technically oriented fields such as computer science, engineering, mathematics and automation control systems.

JMVLSC is mainly focused on the publication of multiple-valued logic and soft computing works. The related

Table 14 International journal of fuzzy systems

R	AT	TPC-A	RA	TPC-RA
1	JQ Wang	88	Computer Science	2280
2	GW Wei	87	Engineering	986
3	JM Merigó	73	Automation Control Systems	796
4	ZS Xu	56	Mathematics	527
5	PD Liu	52	Science Technology Other Topics	296
6	M Akram	40	Telecommunications	198
7	JM Zhan	39	Operations Research Management Science	191
8	B Davvaz	33	Business Economics	123
9	HY Zhang	32	Instruments Instrumentation	111
10	LG Zhou	31	Environmental Sciences Ecology	98
11	GH Tzeng	31	Physics	87
12	XH Chen	30	Chemistry	58
13	HY Chen	29	Mechanics	51
14	CM Lin	28	Robotics	51
15	SZ Zeng	24	Neurosciences Neurology	40
16	J Ye	22	Materials Science	35
17	SC Tong	21	Remote Sensing	35
18	FY Meng	19	Energy Fuels	34
19	M Casanovas	18	Imaging Science Photographic Technology	33
20	BQ Hu	18	Electrochemistry	31
21	WY Wang	17	Mathematical Computational Biology	24
22	AM Gil-Lafuente	17	Oceanography	24
23	YM Li	16	Social Sciences Other Topics	18
24	LP Zhang	15	Thermodynamics	18
25	MJ Er	15	Transportation	18
26	SF Su	15	Public Environmental Occupational Health	16
27	XL Ma	14	Physical Geography	14
28	J Wang	14	Metallurgy Metallurgical Engineering	13
29	A Khan	13	Water Resources	13
30	CH Lee	13	Psychology	12
31	YH Wang	13	Medical Informatics	11
32	YP Pan	12	Biochemistry Molecular Biology	10
33	CF Hsu	12	Acoustics	9
34	JP Liu	12	Construction Building Technology	9
35	HY Yu	12	Geology	9
36	B Du	12	Biotechnology Applied Microbiology	8
37	WJ Chang	12	Education Educational Research	8
38	DJ Yu	11	Geochemistry Geophysics	8
39	DF Li	11	Information Science Library Science	8
40	CW Chang	11	Optics	8

fields this journal publishes are those that are tolerant of imprecision and uncertainty, and deal with partial or incomplete information. Some of the specific issues that this journal has as its scope are logic, circuits, deep learning, fuzzy logic applications and theoretical aspects, soft computing and data and machine learning. The journal records start in 2003 with the ninth volume, and by the end of 2018, a total of 691 documents were listed in the WoS scientific database. The top citing authors are led by Davvaz with 92 published publications citing the selected journal, followed by Herrera with 79, Kahraman with 31, Garcia with 29 and Akram with 27 papers. The research areas most influenced by this publication are those falling in computer science, mathematics and engineering; some other interesting top citing areas are neurology, linguistics and psychology.

Table 15 International journal of general systems

R	AT	TPC-A	RA	TPC-RA
1	ZS Xu	202	Computer Science	5917
2	RR Yager	166	Engineering	2236
3	ZD Wang	109	Mathematics	1509
4	W Pedrycz	95	Operations Research Management Science	677
5	GW Wei	85	Automation Control Systems	571
6	FE Alsaadi	82	Business Economics	393
7	GJ Klir	73	Science Technology Other Topics	345
8	JY Liang	72	Physics	214
9	JM Merigó	67	Environmental Sciences Ecology	191
10	YH Qian	63	Instruments Instrumentation	118
11	H Bustince	63	Social Sciences Other Topics	116
12	D Dubois	61	Telecommunications	116
13	R Mesiar	61	Mechanics	88
14	YR Liu	58	Psychology	85
15	PD Liu	58	Neurosciences Neurology	71
16	XH Chen	53	Mathematical Computational Biology	67
17	DG Chen	51	Water Resources	65
18	J Ye	49	Information Science Library Science	60
19	H Prade	48	Geology	54
20	XW Liu	47	Mathematical Methods in Social Sciences	52
21	WZ Wu	44	Chemistry	51
22	Y Deng	43	Life Sciences Biomedicine Other Topics	49
23	HY Chen	42	Robotics	47
24	J Abellan	40	Materials Science	46
25	DJ Yu	38	Philosophy	45
26	QH Hu	37	Biochemistry Molecular Biology	43
27	BQ Hu	37	History Philosophy of Science	40
28	HC Liao	34	Transportation	40
29	L Martinez	34	Imaging Science Photographic Technology	33
30	WH Xu	34	Energy Fuels	32
31	SK Oh	33	Government Law	32
32	F Herrera	33	Sociology	27
33	B Davvaz	33	Nuclear Science Technology	26
34	V Novak	32	Remote Sensing	24
35	SK Pal	31	Medical Informatics	23
36	CY Dang	30	Public Administration	23
37	MM Xia	30	Biophysics	22
38	JQ Wang	30	Meteorology Atmospheric Sciences	22
39	YY Yao	30	Marine Freshwater Biology	20
40	JL Uso-Domenech	29	Geography	19

The KNOSYS journal publishes original developments on systems using knowledge-based processes, models, techniques and methods to support decision-making, learning and human action [49]. The journal emphasizes machine and computer developments and manlike interactions. This journal's main scope encompasses big data methods, intelligent human interfaces, recommender systems, support decision systems, artificial and deep learning systems and knowledge engineering. The journal also publishes multidisciplinary research on related human endeavor fields ranging from financial technology to health science. KNOSYS published its first issue in 1987, and until the end of 2018, the journal indexed over 3550 articles in the WoS database. The top citing authors for this journal are Xu with 261 papers, Herrera with 145, Acharya with 142, Pedrycz with 132 and Chen with 127 articles. A

Table 16 International journal of information technology and decision making

R	AT	TPC-A	RA	TPC-RA
1	ZS Xu	103	Computer Science	2230
2	EK Zavadskas	100	Operations Research Management Science	1071
3	E Herrera-Viedma	69	Engineering	871
4	G Kou	53	Business Economics	670
5	GW Wei	53	Mathematics	351
6	HC Liao	50	Science Technology Other Topics	248
7	Y Shi	48	Environmental Sciences Ecology	196
8	JQ Wang	46	Automation Control Systems	141
9	PD Liu	43	Telecommunications	96
10	F Herrera	42	Information Science Library Science	93
11	Z Turskis	42	Energy Fuels	78
12	Y Peng	34	Social Sciences Other Topics	52
13	TY Chen	33	Physics	45
14	JP Li	32	Materials Science	40
15	GH Tzeng	32	Health Care Sciences Services	39
16	FAF Ferreira	31	Transportation	39
17	XH Chen	30	Water Resources	36
18	SZ Zeng	29	Medical Informatics	31
19	FJ Cabrerizo	28	Thermodynamics	30
20	J Antucheviciene	28	Construction Building Technology	29
21	L Tang	25	Chemistry	27
22	JM Merigó	24	Public Environmental Occupational Health	27
23	HY Zhang	24	Education Educational Research	26
24	YC Dong	21	Mechanics	26
25	SY Wang	20	Geology	25
26	YJ Xu	20	Public Administration	22
27	F Chiclana	20	Communication	15
28	FY Meng	18	Forestry	15
29	ZS Hashemkhani	17	Instruments Instrumentation	15
30	IJ Perez	17	Mathematical Methods in Social Sciences	15
31	CJ Rao	17	Neurosciences Neurology	15
32	A Fernandez	16	Mathematical Computational Biology	12
33	GM Keshavarz	16	Meteorology Atmospheric Sciences	12
34	D Ergu	15	Psychology	11
35	HY Chen	15	Oceanography	10
36	KK Lai	15	Robotics	10
37	LA Yu	15	Optics	9
38	FH Wen	14	Agriculture	8
39	L Yu	14	Biodiversity Conservation	8
40	GQ Zhang	14	Geography	8

wide range of technical research areas cite this journal, including computer science, engineering, operations and research management science, as well as medical informatics, biomedicine and public environmental occupational health.

Kybernetes is a multidisciplinary journal that shares original research on systems thinking, more specifically on cybernetics and systems thinking. The aim of Kyb is to close the gap of the understanding on human, social and technological issues, its impact on society and its interdependence. Its wide-ranging publications include studies in diverse domains of the human, social and ecological sciences with a novel focus on sustainability studies and works related to the impact of technology on humanity and society. The first issue of this journal was published in 1972, and by the end of 2018, 3356 documents were

Table 17 International journal of intelligent systems

R	AT	TPC-A	RA	TPC-RA
1	ZS Xu	368	Computer Science	10,242
2	RR Yager	202	Engineering	3154
3	F Herrera	174	Mathematics	1738
4	E Herrera-Viedma	141	Operations Research Management Science	1185
5	JM Merigó	136	Automation Control Systems	725
6	GW Wei	128	Business Economics	601
7	XH Chen	108	Science Technology Other Topics	520
8	W Pedrycz	105	Telecommunications	267
9	PD Liu	87	Environmental Sciences Ecology	242
10	JQ Wang	85	Physics	169
11	L Martinez	83	Information Science Library Science	156
12	R Mesiar	83	Robotics	155
13	H Bustince	80	Neurosciences Neurology	129
14	HY Chen	75	Instruments Instrumentation	110
15	F Chiclana	73	Medical Informatics	102
16	C Kahraman	69	Psychology	101
17	V Torra	67	Social Sciences Other Topics	100
18	LG Zhou	66	Chemistry	99
19	D Dubois	63	Water Resources	96
20	ZM Ma	63	Materials Science	94
21	H Prade	62	Mechanics	88
22	HC Liao	62	Geology	80
23	HY Zhang	62	Energy Fuels	78
24	XW Liu	59	Mathematical Computational Biology	77
25	FY Meng	56	Transportation	77
26	DJ Yu	54	Imaging Science Photographic Technology	59
27	YJ Xu	53	Remote Sensing	55
28	SZ Zeng	53	Agriculture	54
29	J Kacprzyk	52	Education Educational Research	48
30	L Yan	50	Nuclear Science Technology	43
31	YH Qian	48	Public Environmental Occupational Health	42
32	B De Baets	47	Philosophy	41
33	G Beliakov	47	Mathematical Methods in Social Sciences	40
34	SM Chen	46	Electrochemistry	37
35	JY Liang	46	Health Care Sciences Services	37
36	Y Deng	44	Construction Building Technology	33
37	TY Chen	44	Physical Geography	32
38	YC Dong	44	Biochemistry Molecular Biology	31
39	TR Li	42	Thermodynamics	30
40	S Zadrozny	41	Meteorology Atmospheric Sciences	29

included in the WoS. Being a journal with a wider scope, the top citing authors are dissimilar to other specialized journals. The top citing authors for Kyb are Cherruault with 105 citing documents, Lin with 60, Navimipour with 54, Rach with 52 and Wei with 50 articles. The top citing research areas for this journal are similar to the rest of the journals presented, with computer science, mathematics and engineering being the top 3 citing research fields.

SC is a specialized journal on systems solutions and applications based on soft computing techniques, more specifically on evolutionary processes, genetic programming, neural and network science, fuzzy sets, fuzzy systems and chaos systems [50]. The main purpose of the journal is to be the link between diverse disciplines, fostering comparison, extensions and new applications of soft computing techniques. SC's first issue was published in

Table 18 International journal of uncertainty fuzziness and knowledge-based systems

R	AT	TPC-A	RA	TPC-RA
1	ZS Xu	173	Computer Science	7069
2	R Mesiar	135	Engineering	2166
3	JM Merigó	116	Mathematics	1789
4	GW Wei	112	Operations Research Management Science	880
5	E Herrera-Viedma	95	Business Economics	492
6	F Herrera	83	Telecommunications	434
7	B De Baets	69	Automation Control Systems	414
8	V Torra	69	Science Technology Other Topics	341
9	RR Yager	69	Environmental Sciences Ecology	195
10	W Pedrycz	68	Mechanics	136
11	H Bustince	61	Physics	129
12	XH Chen	59	Information Science Library Science	104
13	L Martinez	57	Medical Informatics	97
14	YJ Xu	53	Transportation	83
15	HW Liu	52	Instruments Instrumentation	79
16	MR Meybodi	51	Social Sciences Other Topics	75
17	DF Li	51	Mathematical Computational Biology	68
18	FY Meng	48	Mathematical Methods in Social Sciences	68
19	Q Zhang	47	Chemistry	63
20	J Torrens	46	Energy Fuels	60
21	F Chiclana	46	Robotics	60
22	JY Liang	45	Water Resources	58
23	T Chen	45	Acoustics	54
24	HY Chen	44	Health Care Sciences Services	54
25	YH Qian	42	Geology	45
26	PD Liu	42	Public Environmental Occupational Health	45
27	G Beliakov	42	Psychology	33
28	D Dubois	41	Education Educational Research	29
29	M Grabisch	40	Electrochemistry	29
30	LG Zhou	40	Materials Science	29
31	YG Zhu	40	Neurosciences Neurology	29
32	YK Liu	39	Biochemistry Molecular Biology	28
33	HC Liao	39	Government Law	26
34	YC Dong	39	Geography	25
35	XW Liu	37	Physical Geography	25
36	XF Zhao	35	Philosophy	24
37	CY Chen	35	Remote Sensing	23
38	CW Chen	34	Radiology Nuclear Medicine Medical Imaging	20
39	SZ Zeng	33	Biotechnology Applied Microbiology	19
40	Y Deng	33	Construction Building Technology	19

April 1997. By the end of 2018, the WoS included 3342 documents from the journal. The top five citing authors are Herrera with 172 documents, Davvaz with 115, Zhan with 103, Pedrycz with 88 and Herrera-Viedma with 87 citing articles. Computer science, engineering, mathematics, operations research management science and telecommunications are some of the top citing research fields for this publication.

3.2 Aggregated Analyses of the Selected Journals

Tables 25, 26, 27 present aggregated overviews of the individual results. Table 25 is constructed considering the information of authors presented in Tables 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24. The 40 resultant authors are ranked by the sum of their citations of the selected journals, i.e., total citations.

Table 19 Iranian journal of fuzzy systems

R	AT	TPC-A	RA	TPC-RA
1	GW Wei	71	Computer Science	795
2	B Davvaz	56	Mathematics	785
3	FG Shi	36	Engineering	197
4	B Pang	28	Science Technology Other Topics	126
5	JM Zhan	20	Automation Control Systems	73
6	M Aslam	20	Operations Research Management Science	44
7	SM Taheri	18	Physics	24
8	ZY Xiu	18	Energy Fuels	23
9	M Akram	17	Telecommunications	23
10	SA Solovyov	16	Business Economics	21
11	YB Jun	14	Mechanics	15
12	AB Saeid	14	Instruments Instrumentation	14
13	I Cristea	13	Environmental Sciences Ecology	9
14	R Ameri	12	Thermodynamics	8
15	M Shabir	12	Robotics	7
16	T Allahviranloo	12	Agriculture	6
17	M Maiti	11	Geology	6
18	MG Akbari	11	Water Resources	6
19	S Hoskova-Mayerova	11	Mining Mineral Processing	5
20	G Jager	10	Transportation	5
21	J Tang	10	Information Science Library Science	4
22	V Leoreanu-Fotea	10	Mathematical Computational Biology	4
23	OS Fard	9	Social Sciences Other Topics	4
24	E Savas	9	Chemistry	3
25	M Pal	9	Construction Building Technology	3
26	M Arefi	8	General Internal Medicine	3
27	MA Gil	8	Imaging Science Photographic Technology	3
28	A Khan	8	Meteorology Atmospheric Sciences	3
29	J Martinez-Moreno	8	Neurosciences Neurology	3
30	B Sinova	8	Public Environmental Occupational Health	3
31	N Cagman	8	Radiology Nuclear Medicine Medical Imaging	3
32	H Hassanpour	8	Endocrinology Metabolism	2
33	M Lu	8	Health Care Sciences Services	2
34	A Tepavcevic	8	Materials Science	2
35	MM Zahedi	8	Mathematical Methods in Social Sciences	2
36	EH Sadrabadi	7	Medical Informatics	2
37	JW Gao	7	Metallurgy Metallurgical Engineering	2
38	AV Kamyad	7	Nuclear Science Technology	2
39	P Kumam	7	Optics	2
40	QG Li	7	Pediatrics	2

Moreover, the table presents the number of times each author appears in the 22 individual tables and depending on the case, the number of times they occupy the first, second or third position. Additional information including the maximum position reached by the author for any of the NTFSTJ, the maximum number of citations of any of the selected NTFSTJ and the most cited journal of the author is also included.

In general, Xu leads the ranking with a total of 3563 citations, which represents 35% more documents than the next author, Pedrycz, with a total sum of 2646 citations, followed closely by Herrera with 2162 documents and Merigó with a total of 1394 studies citing the journals. Xu is in the first place of the individual results 5 times more than Pedrycz with a total of 4 first places and Wang with 2. For the rest of the top citing authors, only 5 achieve a first

Table 20 Journal of intelligent and fuzzy systems

R	AT	TPC-A	RA	TPC-RA
1	ZS Xu	138	Computer Science	6240
2	PD Liu	122	Engineering	2626
3	B Davvaz	115	Mathematics	1602
4	JQ Wang	115	Automation Control Systems	700
5	GW Wei	92	Science Technology Other Topics	669
6	J Ye	90	Operations Research Management Science	607
7	M Akram	88	Telecommunications	466
8	XH Chen	76	Business Economics	270
9	JM Zhan	76	Environmental Sciences Ecology	239
10	H Garg	75	Physics	214
11	HC Liao	72	Instruments Instrumentation	197
12	HY Zhang	65	Energy Fuels	187
13	JM Merigó	59	Chemistry	134
14	Y Deng	57	Materials Science	122
15	C Kahraman	55	Mechanics	112
16	M Pal	53	Robotics	108
17	E Herrera-Viedma	47	Thermodynamics	78
18	RA Borzooei	44	Neurosciences Neurology	77
19	T Niknam	42	Mathematical Computational Biology	67
20	FG Shi	42	Transportation	67
21	SM Mousavi	41	Electrochemistry	58
22	J Wang	40	Water Resources	56
23	F Herrera	39	Medical Informatics	49
24	H Rashmanlou	38	Construction Building Technology	48
25	W Pedrycz	37	Geology	47
26	MH Khooban	36	Imaging Science Photographic Technology	45
27	FY Meng	34	Optics	39
28	R Tavakkoli-Moghaddam	34	Information Science Library Science	36
29	EK Zavadskas	32	Biochemistry Molecular Biology	34
30	AB Saeid	31	Remote Sensing	31
31	W Jiang	30	Social Sciences Other Topics	31
32	SP Wan	30	Public Environmental Occupational Health	30
33	A Khan	30	Psychology	29
34	A Kumar	29	Biotechnology Applied Microbiology	25
35	DJ Yu	28	Acoustics	23
36	F Chiclana	28	Nuclear Science Technology	23
37	DF Li	26	Meteorology Atmospheric Sciences	22
38	A Baykasoglu	25	Health Care Sciences Services	20
39	I Kaya	24	Education Educational Research	19
40	Y Xue	22	Oceanography	19

position in the individual results. Merigó leads the "times appearing" count by appearing in 18 of the 22 individual tables, followed by Xu, Herrera and Liu with 17 appearances each. For the individual maximum number of citations of a journal, Pedrycz leads the count with 608 total documents citing FSS, followed by Xu with a sum of 430 documents citing INS, Shi with 354 citations of TFUZZ and Herrera and Mesiar, both with 324 total publications citing INS and FSS, respectively.

Tables 26 and 27 present aggregated results ranked by top citing authors and top citing research areas for each of the 22 NTFSTJs, respectively. As observed before, Xu, Pedrycz, Herrera, Merigó and Herrera-Viedma are the leading citing authors, while computer science, engineering, mathematics, operations research and management

Table 21 Journal of multiple-valued logic and soft computing

R	AT	TPC-A	RA	TPC-RA
1	B Davvaz	92	Computer Science	1268
2	F Herrera	79	Mathematics	409
3	C Kahraman	31	Engineering	313
4	S Garcia	29	Science Technology Other Topics	259
5	M Akram	27	Operations Research Management Science	79
6	A Fernandez	26	Automation Control Systems	62
7	JM Zhan	24	Physics	59
8	LC Ciungu	21	Business Economics	42
9	I Chajda	20	Telecommunications	31
10	J Luengo	18	Chemistry	16
11	S Mirvakili	18	Mathematical Computational Biology	16
12	M Couceiro	17	Environmental Sciences Ecology	12
13	MJ del Jesus	16	Instruments Instrumentation	12
14	E Herrera-Viedma	16	Neurosciences Neurology	10
15	M Galar	16	Robotics	9
16	RA Borzooei	16	Optics	8
17	AB Saeid	16	Energy Fuels	7
18	H Bustince	15	Philosophy	7
19	CJ Carmona	14	Biochemistry Molecular Biology	5
20	A Dvurecenskij	14	Electrochemistry	5
21	B Oztaysi	14	Materials Science	5
22	T Waldhauser	13	Medical Informatics	5
23	S Ventura	13	Biotechnology Applied Microbiology	4
24	XL Xin	13	Geology	4
25	I Triguero	12	Information Science Library Science	4
26	M Farshi	11	Life Sciences Biomedicine Other Topics	4
27	V Leoreanu-Fotea	11	Transportation	4
28	L Godo	10	Construction Building Technology	3
29	XH Zhang	10	Imaging Science Photographic Technology	3
30	I Cristea	10	Mathematical Methods In Social Sciences	3
31	E Barrenechea	9	Mechanics	3
32	FJ Cabrerizo	9	Research Experimental Medicine	3
33	V Lopez	9	Water Resources	3
34	L Sanchez	9	Food Science Technology	2
35	J Alcala-Fdez	9	Health Care Sciences Services	2
36	A Cano	9	Linguistics	2
37	F Esteva	9	Meteorology Atmospheric Sciences	2
38	G Georgescu	9	Pharmacology Pharmacy	2
39	J Kuhr	9	Psychology	2
40	L Martinez	9	Social Sciences Other Topics	2

sciences are the leading research areas citing the selected journals. Both tables show the influence that certain academic journals have on the ideas presented in articles, letters, reviews and notes published by the discussed authors and research areas.

4 Conclusions

This study presents a citation analysis of 22 narrowly targeted fuzzy set theory journals using bibliometric tools for the quantification and presentation of the retrieved data. The aims and scope of the selected journals clearly follow a fuzzy systems alignment, as demonstrated in [9, 24]. The analysis is focused on top citing authors and research areas.

Table 22 Knowledge-based systems

R	AT	TPC-A	RA	TPC-RA
1	ZS Xu	261	Computer Science	19,347
2	F Herrera	145	Engineering	8732
3	UR Acharya	142	Operations Research Management Science	2647
4	W Pedrycz	132	Mathematics	1990
5	XH Chen	127	Telecommunications	1543
6	E Herrera-Viedma	120	Business Economics	1535
7	PD Liu	115	Science Technology Other Topics	1408
8	H Fujita	113	Automation Control Systems	1163
9	Y Deng	93	Environmental Sciences Ecology	752
10	JM Merigó	87	Information Science Library Science	675
11	JQ Wang	86	Physics	643
12	GW Wei	84	Energy Fuels	545
13	HY Chen	79	Chemistry	451
14	LG Zhou	77	Instruments Instrumentation	421
15	Y Zhang	76	Mathematical Computational Biology	399
16	TR Li	74	Neurosciences Neurology	366
17	F Chiclana	64	Medical Informatics	361
18	HY Zhang	63	Materials Science	337
19	L Martinez	62	Psychology	312
20	EK Zavadskas	61	Education Educational Research	293
21	H Bustince	60	Social Sciences Other Topics	271
22	C Kahraman	58	Mechanics	253
23	H Li	56	Transportation	232
24	SP Wan	56	Remote Sensing	220
25	FY Meng	55	Thermodynamics	211
26	JJ Jung	54	Imaging Science Photographic Technology	205
27	XW Liu	52	Electrochemistry	178
28	S Garcia	51	Water Resources	177
29	YC Dong	50	Geology	175
30	GH Tzeng	49	Robotics	166
31	U Yun	47	Biochemistry Molecular Biology	154
32	SM Mousavi	47	Radiology Nuclear Medicine Medical Imaging	145
33	JZ Wang	45	Health Care Sciences Services	144
34	SZ Zeng	44	Construction Building Technology	124
35	J Sun	42	Optics	122
36	DJ Yu	41	Life Sciences Biomedicine Other Topics	118
37	JY Liang	40	Biotechnology Applied Microbiology	113
38	D Sanchez	40	Agriculture	100
39	W Wang	39	Physical Geography	97
40	LC Jiao	39	Public Environmental Occupational Health	97

The aim is to advance the knowledge on networks, connections and influence that the selected journals present on both academics and research fields. These connections assemble a general picture that allows the visualization of possible synergies and emerging scientific opportunities for scholars and practitioners.

The data were retrieved from the WoS scientific database. This source was chosen because of the robust and rigorous indexing of scientific material along with its vast collection of specialized materials. The retrieved data were collected by searching for the publication name in the main search engine of the WoS database. Then a series of filters were applied to identify documents relevant for this analysis. From there, a citation analysis report was retrieved focusing on both top citing authors and most citing research areas. The retrieved raw data were then collected

Table 23 Kybernetes

R	AT	TPC-A	RA	TPC-RA
1	Y Cherruault	105	Computer Science	2415
2	Y Lin	60	Mathematics	1144
3	NJ Navimipour	54	Engineering	997
4	R Rach	52	Business Economics	833
5	GW Wei	50	Science Technology Other Topics	325
6	SF Liu	49	Operations Research Management Science	301
7	M Mulej	48	Environmental Sciences Ecology	264
8	AM Wazwaz	41	Physics	246
9	H Prade	40	Social Sciences Other Topics	242
10	D Kaya	39	Automation Control Systems	154
11	M Dehghan	39	Psychology	144
12	JS Duan	38	Information Science Library Science	132
13	A Adamatzky	32	Education Educational Research	111
14	G Adomian	31	Mechanics	110
15	D Dubois	31	Telecommunications	75
16	AM Andrew	30	Chemistry	72
17	M Yolles	29	Energy Fuels	71
18	JL Uso-Domenech	28	Philosophy	71
19	R Ostermark	27	Public Administration	65
20	D Aerts	27	Mathematical Computational Biology	59
21	M Lloret-Climent	26	Neurosciences Neurology	49
22	RR Yager	25	History Philosophy of Science	46
23	JA Nescolarde-Selva	23	Thermodynamics	45
24	U Fidelman	22	Water Resources	44
25	J Kacprzyk	22	Life Sciences Biomedicine Other Topics	41
26	S Momani	21	Robotics	39
27	M Inc	21	Materials Science	37
28	G Mora	20	Mathematical Methods in Social Sciences	36
29	R Espejo	20	Medical Informatics	36
30	AM Gil	19	Sociology	34
31	H Nechansky	19	Instruments Instrumentation	32
32	V Valentinov	19	Biochemistry Molecular Biology	31
33	JA Johannessen	18	Transportation	30
34	Y Deng	18	Public Environmental Occupational Health	27
35	GP Du	17	Geology	26
36	NS Gong	17	Communication	24
37	ET Lee	17	Construction Building Technology	23
38	SE Serrano	17	Government Law	21
39	WJ Zhu	17	Art	19
40	J Belak	17	Geography	19

and treated. For the research area information, the process was straightforward; however, deeper insight into the author results was required, mainly because of the overlap in common surnames. After the treatment of the raw data, the results were presented accordingly.

Aggregated results for top citing authors of the 22 NTFSTJ placed Xu in the first position of the ranking, with a total of 3563 citing documents and INS being the most cited journal for this author, followed by Pedrycz with a total of 2646 documents and FSS being his most cited journal, Herrera with 2162 papers and INS as his most cited journal, Merigó with 1394 and INS as the top citing periodical, Herrera-Viedma with 1378 articles and INS his most cited publication, Yager in sixth place with 1340 and FSS as his top cited journal, Chen with 1314 documents and ESWA as his top cited journal, Liu with 1303 and FSS

Table 24 Soft computing

R	AT	TPC-A	RA	TPC-RA
1	F Herrera	172	Computer Science	11,654
2	B Davvaz	115	Engineering	4442
3	JM Zhan	103	Mathematics	2484
4	W Pedrycz	88	Operations Research Management Science	1279
5	E Herrera-Viedma	87	Telecommunications	958
6	ZS Xu	75	Automation Control Systems	907
7	JQ Wang	67	Science Technology Other Topics	907
8	XH Chen	57	Physics	412
9	S Ventura	53	Business Economics	368
10	R Mesiar	53	Chemistry	300
11	A Dvurecenskij	50	Instruments Instrumentation	286
12	I Chajda	50	Environmental Sciences Ecology	275
13	S Garcia	49	Energy Fuels	242
14	SX Yang	49	Mathematical Computational Biology	211
15	JM Merigó	45	Mechanics	211
16	AB Saeid	44	Materials Science	201
17	S Das	43	Robotics	198
18	A Fernandez	43	Neurosciences Neurology	157
19	YB Jun	43	Imaging Science Photographic Technology	139
20	H Bustince	41	Water Resources	137
21	M Shabir	39	Thermodynamics	122
22	XL Ma	38	Remote Sensing	119
23	B De Baets	37	Biochemistry Molecular Biology	115
24	O Castillo	37	Geology	115
25	LC Jiao	36	Electrochemistry	113
26	FY Meng	35	Transportation	109
27	HC Liu	35	Optics	83
28	PN Suganthan	34	Medical Informatics	75
29	YJ Xu	34	Information Science Library Science	63
30	MJ Del Jesus	33	Construction Building Technology	56
31	A Abraham	33	Meteorology Atmospheric Sciences	55
32	LG Zhou	33	Agriculture	52
33	ST Wang	32	Biotechnology Applied Microbiology	48
34	E Cuevas	32	Physical Geography	46
35	HY Chen	32	Social Sciences Other Topics	45
36	T Allahviranloo	32	Life Sciences Biomedicine Other Topics	42
37	YS Ong	32	Radiology Nuclear Medicine Medical Imaging	39
38	O Cordon	31	Pharmacology Pharmacy	38
39	V Leoreanu-Fotea	30	Geochemistry Geophysics	35
40	L Martinez	30	Philosophy	34

as his main influencing periodical, Wei with 1216 and ESWA being his most influential journal and Mesiar with 1151 studies and FSS as the top citing journal. These aggregated results added the number of documents citing a specific journal; therefore, 1 document may be citing 2 or more of the selected publications; hence, the total sum of the documents presented might be larger than the number of papers produced by these academics. It is interesting that these 10 authors represent 50% of the total citing documents for the 34,599 top 40 aggregated results. In addition, INS is the most cited journal from the top 40 citing authors with 5781 total documents and 33 of the 40 top citing authors, followed by FSS with 4928 citations with 24 top citing authors, ESWA with 3222 and 20 top citing authors, TFUZZ with 3117 and 16 top citing authors, and INT with

Table 25 Top 40 in-depth authors analysis

R	AT	TPC-NTFSTJ	TA	1st P	2nd P	3rd P	Max P	Max C	Max C-J
1	ZS Xu	3563	17	9	5		1	430	INS
2	W Pedrycz	2646	16	4	1		1	608	FSS
3	F Herrera	2162	17	1	3	3	1	324	INS
4	JM Merigó	1394	18		1	2	2	141	INS
5	E Herrera-Viedma	1378	15		1	1	2	188	INS
6	RR Yager	1340	10		2		2	302	FSS
7	XH Chen	1314	16				4	205	ESWA
8	PD Liu	1303	17		1	1	2	146	FSS
9	GW Wei	1216	15	1	2		1	143	ESWA
10	R Mesiar	1151	9		1	1	2	324	FSS
11	JQ Wang	1040	14	2		1	1	154	ESWA
12	H Bustince	935	12				9	175	FSS
13	C Kahraman	916	10			1	3	193	ESWA
14	B Davvaz	844	8	1	2	1	1	220	INS
15	O Castillo	733	6			1	3	195	INS
16	SM Chen	713	7	1			1	185	FSS
17	P Shi	705	3			1	3	354	TFUZZ
18	D Dubois	658	8				6	215	FSS
19	Y Deng	651	12				9	190	ESWA
20	EK Zavadskas	646	7	1	1		1	292	ESWA
21	A Kumar	633	5			1	3	234	ESWA
22	SC Tong	622	4				4	262	TFUZZ
23	B De Baets	617	7				7	199	FSS
24	GH Huang	607	4				4	303	FSS
25	HY Chen	577	12				5	111	INS
26	L Martinez	550	11				6	103	INS
27	H Prade	546	7				9	185	FSS
28	JM Zhan	540	7			1	3	158	INS
29	Y Xu	498	4				5	223	INS
30	YM Li	430	3				5	219	TFUZZ
31	UR Acharya	426	3			1	3	157	ESWA
32	LG Zhou	418	9				10	87	ESWA
33	HY Zhang	367	8				9	65	JIFS
34	JP Xu	362	4				16	117	INS
35	P Melin	359	3				11	146	INS
36	ZD Wang	356	3			1	3	145	TFUZZ
37	JY Liang	349	6				8	103	INS
38	HC Liao	348	7			1	3	72	JIFS
39	M Akram	345	5				5	173	INS
40	FY Meng	341	9				8	56	INT

TPC-NTFSTJ sum of publications citing the 22 NTFSTJ, *TA* times appearing in the top 40 of the individual tables, *1st P* times appearing in 1st position, *2nd P* times appearing in 2nd position, *3th P* times appearing in 3rd position, *Max P* maximum position reached in the individual tables, *Max C* maximum number of citations to a journal, *Max C-J* most cited journal

a total of 2478 citations with a total of 25 top citing authors.

The results obtained for research areas clearly identify computer science as the top citing research field, with a total of 283,438 documents citing ESWA as the most cited journal for this specific field. Engineering is the next top citing area, with a total of 163,183 documents citing this field of knowledge. ESWA is also the top citing journal for

Table 26 Aggregated results by author and journal

R	AT	ASOC	C&S	ESWA	FODM	FSS	IASC	TFUZZ	INFFUS	IJAR	IJCIS	IJFS	IJGS
1	ZS Xu	170		251	160	390		365	132	225	64	56	202
2	W Pedrycz	183	15	205	17	608		419	28	165	22		95
3	F Herrera	104		156	26	244		211	110	155	65		33
4	JM Merigó	105	65	95	35	113		105	31	50	47	73	67
5	E Herrera-Viedma	79			59	171		138	59	84	25		
6	RR Yager		15		44	302		166		92			166
7	XH Chen	121		205	41	130			58	49	35	30	53
8	PD Liu	109	26	106	22	146		108	60	40	67	52	58
9	GW Wei	88		143	41				31	81	70	87	85
10	R Mesiar					324		155	30	102			61
11	JQ Wang	78		154	35		12		62		77	88	30
12	H Bustince					175		145	39	79	21		63
13	C Kahraman	70		193	25	191					55		
14	B Davvaz					180						33	33
15	O Castillo	129		141		101		130					
16	SM Chen		90	113		185		115		41			
17	P Shi					133		354					
18	D Dubois		14			215				91			61
19	Y Deng	70	18	190					25	42	18		43
20	EK Zavadskas	114		292	19						28		
21	A Kumar	124		234		100							
22	SC Tong					216		262				21	
23	B De Baets					199		80		70			
24	GH Huang			124		303				41			
25	HY Chen				25				61	42	22	29	42
26	L Martinez				22				33	57	60		34
27	H Prade		16			185				67			48
28	JM Zhan					120						39	
29	Y Xu			154		91					30		
30	YM Li							219				16	
31	UR Acharya			157									
32	LG Zhou			87	19				48		17	31	
33	HY Zhang	55							27		39	32	
34	JP Xu			111	28	106							
35	P Melin	102		111									
36	ZD Wang							145					109
37	JY Liang									43			72
38	HC Liao				47				44				34
39	M Akram											40	
40	FY Meng				38				38			19	
–	Total	1701	259	3222	703	4928	12	3117	916	1616	762	646	1389
–	Number of Authors	16	8	20	18	24	1	16	18	20	18	15	20

R	AT	INT	IJITDM	IJUFKS	IrJFS	INS	JIFS	JMVLSC	KNOSYS	Kyb	SC	Total
1	ZS Xu	368	103	173		430	138		261		75	3563
2	W Pedrycz	105		68		459	37		132		88	2646
3	F Herrera	174	42	83		324	39	79	145		172	2162
4	JM Merigó	136	24	116		141	59		87		45	1394

Table 26 continued

R	AT	INT	IJITDM	IJUFKS	IrJFS	INS	JIFS	JMVLSC	KNOSYS	Kyb	SC	Total
5	E Herrera-Viedma	141	69	95		188	47	16	120		87	1378
6	RR Yager	202		69		259				25		1340
7	XH Chen	108	30	59		135	76		127		57	1314
8	PD Liu	87	43	42		100	122		115			1303
9	GW Wei	128	53	112	71		92		84	50		1216
10	R Mesiar	83		135		208					53	1151
11	JQ Wang	85	46			105	115		86		67	1040
12	H Bustince	80		61		156		15	60		41	935
13	C Kahraman	69				169	55	31	58			916
14	B Davvaz				56	220	115	92			115	844
15	O Castillo					195					37	733
16	SM Chen	46				123						713
17	P Shi					218						705
18	D Dubois	63		41		142				31		658
19	Y Deng	44		33			57		93	18		651
20	EK Zavadskas		100				32		61			646
21	A Kumar					146	29					633
22	SC Tong					123						622
23	B De Baets	47		69		115					37	617
24	GH Huang					139						607
25	HY Chen	75	15	44		111			79		32	577
26	L Martinez	83		57		103		9	62		30	550
27	H Prade	62				128				40		546
28	JM Zhan				20	158	76	24			103	540
29	Y Xu					223						498
30	YM Li					195						430
31	UR Acharya					127			142			426
32	LG Zhou	66		40					77		33	418
33	HY Zhang	62	24				65		63			367
34	JP Xu					117						362
35	P Melin					146						359
36	ZD Wang					102						356
37	JY Liang	46		45		103			40			349
38	HC Liao	62	50	39			72					348
39	M Akram				17	173	88	27				345
40	FY Meng	56	18	48			34		55		35	341
–	Total	2478	617	1429	164	5781	1348	293	1947	164	1107	34,599
–	Number of Authors	25	13	20	4	33	19	8	20	5	17	358

this area. The research area of mathematics has 63,198 papers cited, and FSS is the most cited journal. Operations research & management science is the next top citing field, with 47,763 citations, and ESWA is the most cited journal of this research field. Automation control systems is the fifth top citing research area, with 37,145 studies, and TFUZZ is the top citing publication. Business economics follows with 23,511 studies, and ESWA is its top cited reference. In general, 59% of the total studies citing the selected journals fall in two main disciplines, computer science and engineering. From these results, 38% of the top 40 studies belong to the computer science field. Of the 22 selected journals, ESWA, INS, FSS, ASOC and TFUZZ are the 5 most cited journals from the top 40 aggregated results of the research fields.

This study tries to shed light on the use of citation analysis for the in-depth characterization of bibliometric studies. The motivation of this study lies in the proposition

Table 27 Aggregated results by research area and journal

R	RA	ASOC	C&S	ESWA	FODM	FSS	IASC	TFUZZ	INFFUS	IJAR	IJCIS	IJFS	IJGS
1	Computer Sc	23,884	2736	54,708	2100	35,264	708	23,659	5469	11,116	2631	2280	5917
2	Engineering	18,751	1151	48,917	693	17,302	527	15,769	3215	3503	1101	986	2236
3	Mathematics	3622	572	6895	538	15,668	97	5976	579	2539	460	527	1509
4	Op Res Manag Sc	4112	397	17,659	537	5440	55	2583	464	1218	335	191	677
5	Autom Control Systems	2857	303	5417	150	5542	366	8519	521	768	224	796	571
6	Business Econ	1533	309	9697	180	2509	20	653	181	511	198	123	393
7	Science Tech Other Topics	2717	160	6539	143	2214	64	1078	355	628	311	296	345
8	Telecomm	2236	115	4595	73	751	98	1269	1013	279	178	198	116
9	Environmental Sciences Ecol	1531	163	5459	67	1786	45	443	181	363	121	98	191
10	Instruments Instrumentation	1340	72	3116	9	1209	91	2099	678	157	47	111	118
11	Physics	1169	126	2545	27	931	34	705	322	179	67	87	214
12	Energy Fuels	2202	40	3727	32	722	32	440	70	133	54	34	32
13	Chemistry	1091	46	2758	7	439	69	378	427	108	45	58	51
14	Mechanics	1226	54	1915	31	1032	16	822	52	104	46	51	88
15	Materials Sc	1163	39	2452	12	478	37	309	100	78	42	35	46
16	Transportation	602	34	2371	14	556	11	290	145	92	83	18	40
17	Information Sc Library Sc	203	76	2318	9	266		92	57	95	26	8	60
18	Water Resources	809	36	1741	28	859	9	206	31	140	32	13	65
19	Mathematical Computational Biology	628	72	1587	2	231	12	273	108	159	27	24	67
20	Robotics	525	103	803	21	538	95	685	119	130	28	51	47
	Total	72,201	6604	185,219	4673	93,737	2386	66,248	14,087	22,300	6056	5985	12,783

R	RA	INT	IJITDM	IJUFKS	IrJFS	INS	JIFS	JMVLSC	KNOSYS	Kyb	SC	Total
1	Computer Sc	10,242	2230	7069	795	51,706	6240	1268	19,347	2415	11,654	283,438
2	Engineering	3154	871	2166	197	25,534	2626	313	8732	997	4442	163,183
3	Mathematics	1738	351	1789	785	11,924	1602	409	1990	1144	2484	63,198
4	Op Res Manag Sc	1185	1071	880	44	6002	607	79	2647	301	1279	47,763
5	Autom Control Systems	725	141	414	73	6772	700	62	1163	154	907	37,145
6	Business Econ	601	670	492	21	2372	270	42	1535	833	368	23,511
7	Science Tech Other Topics	520	248	341	126	3366	669	259	1408	325	907	23,019
8	Telecomm	267	96	434	23	4843	466	31	1543	75	958	19,657
9	Environmental Sciences Ecol	242	196	195	9	1415	239	12	752	264	275	14,047
10	Instruments Instrumentation	110	15	79	14	2081	197	12	421	32	286	12,294
11	Physics	169	45	129	24	2344	214	59	643	246	412	10,691
12	Energy Fuels	78	78	60	23	1145	187	7	545	71	242	9954

Table 27 continued

R	RA	INT	IJITDM	IJUFKS	IrJFS	INS	JIFS	JMVLSC	KNOSYS	Kyb	SC	Total
13	Chemistry	99	27	63	3	1291	134	16	451	72	300	7933
14	Mechanics	88	26	136	15	1275	112	3	253	110	211	7666
15	Materials Sc	94	40	29	2	859	122	5	337	37	201	6517
16	Transportation	77	39	83	5	527	67	4	232	30	109	5429
17	Information Sc Library Sc	156	93	104	4	743	36	4	675	132	63	5220
18	Water Resources	96	36	58	6	532	56	3	177	44	137	5114
19	Mathematical Computational Biology	77	12	68	4	928	67	16	399	59	211	5031
20	Robotics	155	10	60	7	682	108	9	166	39	198	4579
	Total	19,873	6295	14,649	2180	126,341	14,719	2613	43,416	7380	25,644	755,389

of [9], where fuzzy set theory journals are clearly identified by bibliometric indicators; more specifically, the percentage of fuzzy set theory papers published in a journal. The aim is to provide a picture of the citing authors and research areas of the selected NTFSTJ based on a characteristic search process involving the citation report feature of the selected database and a careful manual revision of the obtained data. These characteristics allow us to first identify which sources influence the leading authors of the field the most, therefore providing a broad picture of the extension of the ideas presented in the journal. Second, these characteristics allow us to view which research areas are citing which journal; this result is interesting, as the reader can observe which kind of public readership the journal is attracting and identify, beyond the three main positions, which journals show a citation attraction for areas that might be involved in new opportunities and fields of knowledge.

The present study has some limitations. First, the extracted raw data pool of documents is mainly extracted from the WoS. Second, to achieve the clear identification of authors with similar surnames in this analysis, a manual detailed scrutiny was required; however, some documents might have been omitted due to the validation process. Third, the current counting method for CP is one on one; i.e., a citing paper is added to the accumulated sum if there is one or more citations for any of the NTFSTJ, which may hinder some data and possibly affect some rankings. Further research is required to tackle these limitations, especially regarding the selection on the sources of information, as other scientific catalogs should be included [51] to expand the analysis, e.g., SCOPUS and Google Scholar, to expand the number of documents to be analyzed in the research, adding other NTFSTJs that this study has not covered. Also, the need for a deeper content analysis is evidenced, i.e., further developments are encouraged to analyze the proposals in terms of most cited papers or most influential ideas and for extracting the citations of a document to eliminate the limitation of the one-for-one current method of counting.

Fuzzy set theory and its applications and extensions present exponential growth in both their publications and impact [52]. The quantification and analysis of this expansion is interesting because it focuses on the academic leaders and research fields that are being influenced by the documents disseminated by the journals. The connections, networks and research paths are additional results of this study that allow the visualization of possible synergies and opportunities for research in emerging fields. This study intends to shed light on the scope of fuzzy set theory and its evolution, its influence on diverse minds and fields, and its prospects for future developments.

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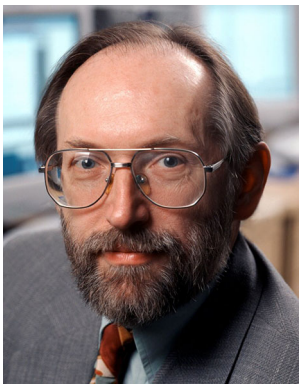

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